OBSERVATIONS ON THE ANIMAL LIFE OF SOME ZAMBIAN HOT SPRINGS[1]

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Three groups of hot springs had maximum temperatures of 63° C–88° C and total dissolved solids of 450 ppm, 1600 ppm, and 1800 ppm. Eight species of invertebrates were found in one or more of these springs, at temperatures of 31° C–53° C. Much the most abundant animals were two species of ostracods (*Eucypris* spp.) found in the more saline springs. Two species were ubiquitous and six were found in only one spring each. Spring habitats were complex and variable and the occurrence of animals was closely correlated with these differences.

There are many hot springs in the Zambezi basin of Zambia. The animal life and physico-chemical conditions in three of these were observed during the course of other work in the area. Gwisho and Bwanda hot springs lie 3 km apart in Lochinvar National Park (16–00 S, 27–15 E), at 1000 m above sea level. Fifty-mile Hot Springs (author's name) is on the Great East Road approximately 80 km east of Lusaka (15–15 S, 29–00 E), at 1200 m above sea level. All three consist of numbers of small springs emerging in dense grass.

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METHODS

Gwisho Hot Springs was visited a number of times in 1967–68, and all three Springs were visited in August-September, 1970 and September, 1971. Water temperatures were measured to ±0.5°C with a YSI Model 42SF Telethermometer with No. 418 probe. Dissolved oxygen was measured by the Winkler method (azide modification), acidity was determined with pH paper, and water samples were collected for chemical analysis.

Ostracods were plainly visible in the springs, and the shells of dead ostracods were visible on dark bottom sediments; their presence and relative abundance were noted on all visits. Other animals also were found in various places. Animals and algae were collected in 1970 and 1971.

RESULTS

Most of the springs are small rounded pools with water welling up from the

FIGURE 1. Spring 10 at Bwanda Hot Springs. The spring is filled with dead grass covered by an algal mat, except where water wells up in the center.

bottom (fig. 1). They range from 20 cm to 2 m in diameter and from 4 cm to more than 1 m in depth. Gas bubbles up from most of the springs. They are drained by small outlet streams. Total dissolved solids at Gwisho were 1800 ppm, at Bwanda 1600 ppm, and at Fifty-mile 450 ppm, based on a single sample each. The pH ranged from 4.0 to 5.5. Dissolved oxygen ranged from 0 ppm to 4 ppm (seven determinations).

Maximum temperatures in each spring ranged from 44.5°C to 78°C at Gwisho, from 51°C to 88°C at Bwanda, and from 40°C to 63°C at Fifty-mile. There was great variation within springs, with differences of as much as 5°C within horizontal distances of one or two centimeters. Such differences were caused either by the complex flow patterns in open water or by the barrier effect of spring vegetation. Vertical temperature differences were slight. Temperatures varied from time to time by as much as 14°C, and dropped rapidly in the outlet streams.

Most springs had a layer of dead grass on the bottom, usually overlain by an algal mat 2–3 mm thick or a layer of dark organic sediment. The algal mats consisted of masses of filamentous blue-green algae, primarily *Oscillatoria* sp., imbedded with diatoms and in some springs many green sulfur bacteria (*Microchloris* sp.). Eight species of invertebrates were found living in the water of one or more springs (table 1). In addition, small gray spiders often were seen running across the surface of the floating algal mats at all three springs, and a water beetle (Dytiscidae) was found on a mat at Bwanda.

Two species were found in all three springs, the other species in only one spring each. The overall temperature range was similar at the three springs, from that of the ambient air to temperatures too hot for animal life. The restricted distribution of most of the animals may have been caused by differences in the chemical content of the water. Ostracods were found only in the more heavily mineralized water at Gwisho and Bwanda. Distribution within each spring was determined largely by temperature, and there is no evidence that pH or dissolved oxygen limited the occurrence of the animals.

TABLE 1

Animals found in the springs, and the temperatures (°C) at which they were living.

	Bwanda	Gwisho	Fifty-mile
Oligochaeta, Naididae			
Nais sp.			43.5
Ostracoda, Cypridae			
Eucypris sp. A	31–52		
Eucypris sp. B		31.5–53	
Anisoptera			
undet., nymph	45		
Diptera			
Dasyhelea sp. (Ceratopogonidae), larvae	41.5–49	46.5	40.5–43.5
Chironomidae, undet., larva			40.5
Acarina			
Nilotonia (s.s.) *thermophila* (Lundblad) (Anisitsiellidae)	44.5	31.5	40–45
Trimalaconothrus sp. (Malaconothridae)			43.5
No. of Species	4	3	5

Dasyhelea was never common, but a few were found in algal mats at all three springs. The temperature range was 40.5°C to 49°C. A single chironomid larva was living with *Dasyhelea* in an algal mat at 40.5°C, and a single dragonfly nymph was living in an outlet stream at 45°C.

The mite *Nilotonia* was found in algal mats at three places at Fifty-mile and one at Bwanda, and in open water at one place at Gwisho. It was always at or just below the surface, at 31.5°C to 45°C. The oligochaete *Nais* and the mite *Trimalaconothrus* were found in an algal mat in a small spring at Fifty-mile, living with *Dasyhelea* and *Nilotonia*. The water temperature was 43.5°C, and there was no measurable dissolved oxygen.

Ostracods were by far the most common of the animals in the springs. Their distribution and abundance at Gwisho and Bwanda were influenced primarily by water temperature, and they were found only at temperatures between 31°C and 53°C. They were rarely found at the extreme temperatures, but were found at most sites with temperatures of 36°C to 50.5°C (*Eucypris* sp. A at 82% of 62 sites, *Eucypris* sp. B at 90% of 21 sites). Populations were also more dense at the intermediate temperatures. Ostracods were influenced by the rate of flow of the water. Fast-flowing water had none, except a few carried along by the current, and the densest populations were in areas of still water.

The springs are complex habitats, with marked changes in temperature, rate of flow, and nature of substrate within a distance of a few millimeters. These differences were reflected in equally great differences in the ostracod populations. Typically the water just emerging from the ground in the center of the spring was too hot for ostracods. Around the sides of the spring and in the outlet streams there was a patchy distribution of ostracods, depending on temperature and flow. Ostracods disappeared from the outlet streams as the temperature dropped.

The algal mat often acted as a mechanical barrier separating the hot water at the center of a spring from the cooler peripheral water. In many springs there were ostracods in the water just outside the floating edge of the mat but none in the much hotter water lying over the mat.

The water currents within a spring or stream were constantly shifting, and the life of the ostracod depended on its remaining in water at a suitable temperature. In one large pool, dense populations were swimming rapidly in water at 48°C, but as the current shifted slightly those on the edge were continually being swept into water at 61°C. These died almost immediately and were swept away by the current.

Ostracod populations varied from time to time. There were great fluctuations in a large pool at Gwisho in 1967–68. In September, 1967 there were many

ostracods living at 48°C in the center of the pool. In 1970 the temperature there was 10°C higher and there were no ostracods, but in 1971 the temperature had fallen to 47°C and ostracods were again common. Populations in a few other pools observed over a period of time showed similar fluctuations.

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